APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: TRANSFORMER SHIELDING

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Transformer Shielding

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention involves no federally sponsored research or development.

BACKGROUND OF THE INVENTION

The invention relates to electrical transformers, and more particularly to shielding of transformers to reduce interference due to electromagnetic radiation.

It is an important object of the invention to provide an improved electrical transformer and transformer shield.

BRIEF SUMMARY OF THE INVENTION

According to the invention, an electrical transformer for converting a first voltage to a second voltage includes a core which includes a first core portion and a second core portion. The electrical transformer device further includes a shielding device, for electrically shielding said first core portion from said second core portion.

In another aspect of the invention, the transformer incorporating the invention is a component in switching circuitry, such as an amplifier or power supply.

In a more specific aspect of the invention, a power supply for an electronic device, includes input terminals for inputting line electrical power, a rectifier, for rectifying said line electrical power to produce rectified electrical power, a switching circuit, for switching said rectified electrical power to produce switched rectified electrical power, a transformer, for modifying said voltage. The transformer includes a core comprising a first core portion and a second core portion and a first shielding device, for electrically shielding said first core portion from said second core portion.

In another aspect of the invention, an electronic device includes an antenna, for receiving radio frequency signals, a tuner, for tuning said radio frequency signals, and a switching power supply, for providing electrical power to said tuner. The switching power supply includes a transformer that has a first core portion, a second core portion, primary windings, and secondary windings. The transformer further includes a shielding device, for electrically shielding said first core portion from said second core portion.

In still another aspect of the invention, an electrical transformer has a first core portion, a second core portions, first windings, and second windings. A shielding device is designed and constructed to shield said first core portion from said second core portion.

Other features, objects, and advantages will become apparent from the following detailed description, which refers to the following drawing in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an isometric view of a transformer assembly incorporating the invention;

FIG. 2 is an exploded isometric view of the transformer assembly of FIG. 1;

FIG. 3 is a first implementation of a transformer shield according to the invention;

FIG. 4 is a cross section of a second implementation of a transformer according to the invention;

FIG. 5 is a third implementation of a transformer according to the invention; and

FIG. 6 is block diagram of an electronic device incorporating the invention.

DETAILED DESCRIPTION

With reference now to the drawing and more particularly to FIG. 1, there is shown a transformer assembly incorporating the invention. Transformer assembly 10 includes a core 12 consisting of two sections 12a and 12b. Primary winding 14 is wound around first core portion

12a, and secondary winding 16 is wound around second core portion 12b. Electrostatic shield 22 electrically isolates primary winding 12 from secondary winding 16 and also electrically isolates core first core portion 12a from second core portion 12b. Electrostatic shield 22 will be discussed more fully below. Plastic bobbin 24 may be provided to hold core portions 12a and 12b in place, to facilitate the formation of the primary and secondary windings, to provide connecting pins 24 for electrical connections to other devices, and to provide a mechanical support for the core portions 12a and 12b.

Referring now to FIG. 2, there is shown an exploded view of the transformer assembly of FIG. 1. First core portion 12a and second core portion 12b are "E" shaped and reverse "E" shaped blocks of a substance, such as ferrite that has a high magnetic permeability. Other shapes for the core portions include "C" and reverse "C" shapes, half-rings, and many others. Electrostatic shield 22 is shaped and positioned such that it lies between the first core portion and the second core portion, and may be further positioned such that it lies between the primary winding and the secondary winding.

Referring to FIG. 3, there is shown one implementation of an electrostatic shield 22. Electrostatic shield 22 includes a substrate 26 of printed circuit board substrate material. On one surface (hereinafter the conductive surface) of the substrate 26 is a pattern 28 of an electrically conductive material such as copper, in a comb-type pattern consisting of parallel traces 29 of copper electrically connected at one end by a connecting trace 32. A drain wire 30 (or some other electrically conductive component) is electrically connected to the connecting trace 32 of the pattern of electrically conductive material and is connectable to a circuit portion which conducts capacitive displacement currents to their source. In addition to comb-type patterns, other patterns of conductive material can be used. A desirable characteristic of the patterns is that they avoid large area loops which would conduct significant eddy currents which could

interfere with the magnetic field of the core 12. In one embodiment of the implementation of FIG. 3, substrate 26 is 0.2 mm thick and 44.7mm wide. There are 148 copper parallel traces 29 that are 0.15 mm wide and separated by 0.15 mm. For clarity, the traces in FIG. 3 are not shown in scale; the number of parallel traces and the dimensions of the traces are as described above. In one embodiment, the electrostatic shield is positioned such that the conductive surface faces the primary winding 14 and first core portion 12a. The implementation of FIG. 3 may be constructed and arranged such that the conductive pattern 28 is in electrical contact with first core portion 12a so that any electrical currents that may occur in first core portion 12a are conducted away by drain wire 30.

Referring to FIG. 4, there is shown a cross section taken along line 4 – 4 of FIG. 2 of a second implementation of the electrostatic shield 22. A thin layer of electrically insulating material 34 (such as 0.2 mm thick polyester is covered with a thin conductive layer 36 (such as indium tin oxide). The thickness and the electrical characteristics of the conductive layer are selected such that the surface conductivity is about 20 ohms per square and so that there are only insignificant eddy currents in the conductive layer which have an insignificant effect on the magnetic field of the core 12. The dimensions and electrical characteristics of the conductive layer are further selected such that there is sufficient electrical conductivity to return capacitive displacement electrical currents to a drain wire 30 so that the capacitive displacement currents can be returned to their source.

Referring to FIG. 5, there is shown a third implementation of electrostatic shield 22. The shield of FIG. 5 is a sheet 37 of substantially uniformly conductive material, with a surface resistivity in the range of 10 ohms to 100 ohms per square. The physical and electrical dimensions of the sheet are selected such that there is sufficient conductivity to return capacitive

displacement currents to drain wire 30, and so that the effect on the magnetic field of the core 12 is insignificant. A sheet of carbon impregnated polymer, 0.2 mm thick is suitable.

Referring to FIG. 6, there is shown a block diagram of an electronic device incorporating a shielded transformer according to the invention. An audio system 40 includes a switching power supply 42 which receives electrical power from a power plug 44 which is connectable to an outside source of electrical power (such as line AC power). Switching power supply 42 converts the line electrical power to electrical power for an audio signal amplification and transduction circuitry 46. The audio signal amplification and transduction circuitry 46 amplifies and transduces to sound waves audio signals from audio signal processor 48. Audio signal processor 48 processes audio signals from a number of sources, including AM/FM tuner 50. AM/FM tuner 52 receives and tunes radio signal received from antenna 52.

Switching power supply 42 includes a first rectifier 54 and a switching circuit 56 coupled to transformer 10 according to the invention. Transformer 10 includes an electrostatic shield 22 positioned between the two core portions 12a and 12b, and between the primary winding 14 and secondary winding 16, with the conductive pattern (28 of FIG. 3 or 36 of FIG. 4) facing primary winding 14 and first core portion 12a. Drain wire 30 connects conductive pattern (28 of FIG. 3 or 36 of FIG. 4) of electrostatic shield 22 to switching circuit 56. Optional second electrostatic shield 22' is positioned between two core portions 12a and 12b and between primary winding 14 and secondary winding 16, with the conductive pattern or layer (28 of FIG. 3 or 36 of FIG. 4) of electrostatic shield 22' facing secondary winding 16 and second core portion 12b. Drain wire 30' of electrostatic shield 22' connects conductive pattern to a common lead 49 to secondary winding 16. Terminals of secondary winding 16 are coupled to second rectifier 58, which is coupled to audio signal amplification and transduction circuitry 16, which amplifies and transduces audio signals received from audio signal processor 48. The switching circuit 56 may

modulate the voltage on the secondary windings 16 by a number of methods, including frequency modulation, pulse modulation, or pulse width modulation, and others. An alternative arrangement of the combination of electrostatic shield 22 and electrostatic shield 22' is a single electrically insulative substrate of sufficient thickness with a first conductive pattern or layer (28 of Fig. 3 or 36 Fig. 4) on a surface of the substrate facing first core portion 12a and primary winding 14 and a second conductive pattern or layer (28 of Fig. 3 or 36 Fig. 4) on a second surface of the substrate facing second core portion 12b and secondary winding 16.

In operation, rectifier 54 rectifies AC line electrical power to DC electrical power. Switching circuit 56 converts the DC electrical power to electrical pulses, typically of a significantly higher frequency than the AC line electrical power. Transformer 10 transforms the electrical pulses to a different, typically lower, voltage. Second rectifier 58 converts the high frequency output of transformer 10 to DC of an appropriate voltage to power audio signal amplification and transduction circuitry 16. Audio signal amplification and transduction circuitry 16 amplifies and transduces audio signals received from audio signal processor 48. The voltage level at the output terminals of rectifier 58 is modulated by the switching circuit 56. Modulation may be done by a number of methods, including frequency modulation, pulse modulation, or pulse width modulation, and others. First electrostatic shield 22 and second electrostatic shield 22' shield conduct any capacitive displacement electrical currents back to the source of the electrical currents, thereby minimizing electro-magnetic radiation from transformer assembly 10.

An electronic device according to the invention is advantageous because capacitive displacement charges between both windings and between core halves are significantly attenuated. There is therefore less need for EMI filtering of power line and output wires. Additionally, since a device incorporating the invention produces less electromagnetic

interference, there is less need for EMI shielding of the device relative to nearby electronic devices components or devices. The shield can be manufactured inexpensively and integrated into the transformer easily. A transformer incorporating the shield has less need for more expensive EMI shielding devices that may be more difficult to assemble and may interfere with other functions, such as preventing overheating of the transformer.

In transformers having more than two core portions, multiple shields may be employed to shield one core portion from two or more other core portions.

A transformer shield according to the invention inhibits capacitive displacement currents flowing between core portions of a transformer without significantly affecting the magnetic properties of the core portions. A transformer incorporating the invention may have significantly less EMI radiation than conventional transformers.

It is evident that those skilled in the art may now make numerous uses of and departures from the specific apparatus and techniques disclosed herein without departing from the inventive concepts. Consequently, the invention is to be construed as embracing each and every novel feature and novel combination of features disclosed herein and limited only by the spirit and scope of the appended claims.

WHAT IS CLAIMED IS: